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MECHANICAL SEED COTTON UNLOADING SYSTEM

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INTRODUCTION

Increased use of mechanical harvesters in the past 10 years has greatly reduced the length of the harvest season and increased the rate of flow of seed cotton to the gin. When a producer delivers a load of seed cotton to the gin yard, he wants his trailer emptied promptly so that it can be returned to the field for reloading. To keep abreast of the farmer's production rate, the ginner is constantly making changes in his plant to increase the efficiency and to eliminate bottlenecks. The objective of this study was to develop a more economical seed cotton unloading system that could keep pace with the ever-increasing demands for higher rates of processing at the gins.

The increased rate capability of high-capacity gin stands has shifted the bottleneck to complementary processing equipment. The bottleneck never remains in one location long because of the never-ending struggle of researchers to increase the efficiency of operation and the rate of processing, to reduce cost of operation, and to maintain the inherent quality of the product at the same time.

Not more than 10 years ago, the pneumatic unloading system handled an average of 6 to 8 thousand pounds of seed cotton per hour, or 4 to 5 bales. The unloading operation and the moving of trailers on the yard required a minimum of two men and the machinery required was only 20 to 30 horsepower.

Today the unloading system of a modern high-capacity gin plant requires the handling of as much as 20 to 25 thousand pounds of seed cotton per hour, or 15 to 20 bales. The labor requirement for this unloading and yard operation is a minimum of 3 to 4 men.[2] The power requirement ranges from 65 to 180 horsepower depending on plant layout, rated plant capacity, and method of harvest.[3]

1/ Research agricultural engineers, U.S. Cotton Ginning Research Laboratory, Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture, Stoneville, Mississippi.

2/ Wilmot, C. A., Stedronsky, V. L., Looney, Z. M., and Moore, V. P. Engineering and Economic Aspects of Cotton Gin Operation -- Midsouth, West Texas, Far West. U.S. Dept. Agr., Econ. Res. Serv., Agr. Econ. Rpt. 116. 44 pp. 1967.

3/ Wilmot, C. A., and Watson, H. Power Requirements and Costs for High-Capacity Cotton Gins. U.S. Dept. Agr. Mktg. Res. Rpt. 763, 23 pp. 1966.

There are plans on the drawing board for the construction in the near future of gin plants capable of processing as much as 60 thousand pounds of seed cotton per hour, or 40 bales. A pneumatic system to handle this volume of material would require two complete and separate unloading systems operating simultaneously to move the mass of seed cotton from the trailer into the gin building at the required rate. This would double the power and labor requirements for the unloading operation.

CONVENTIONAL PNEUMATIC UNLOADING SYSTEM

The conventional pneumatic seed cotton unloading system at the gin consists of an unloading or elevator fan, an unloading separator, and an automatic feed control unit. The elevator fan supplies sufficient quantity of air to a telescoping pipe to remove seed cotton from the trailer by suction and the unloading separator separates seed cotton from the conveying air. The automatic feed control unit consists of a hopper, two vacuum feeder wheels, and a metering device for feeding seed cotton from the hopper into the drying, cleaning, and ginning systems at desired rates. Figure 1 shows a schematic

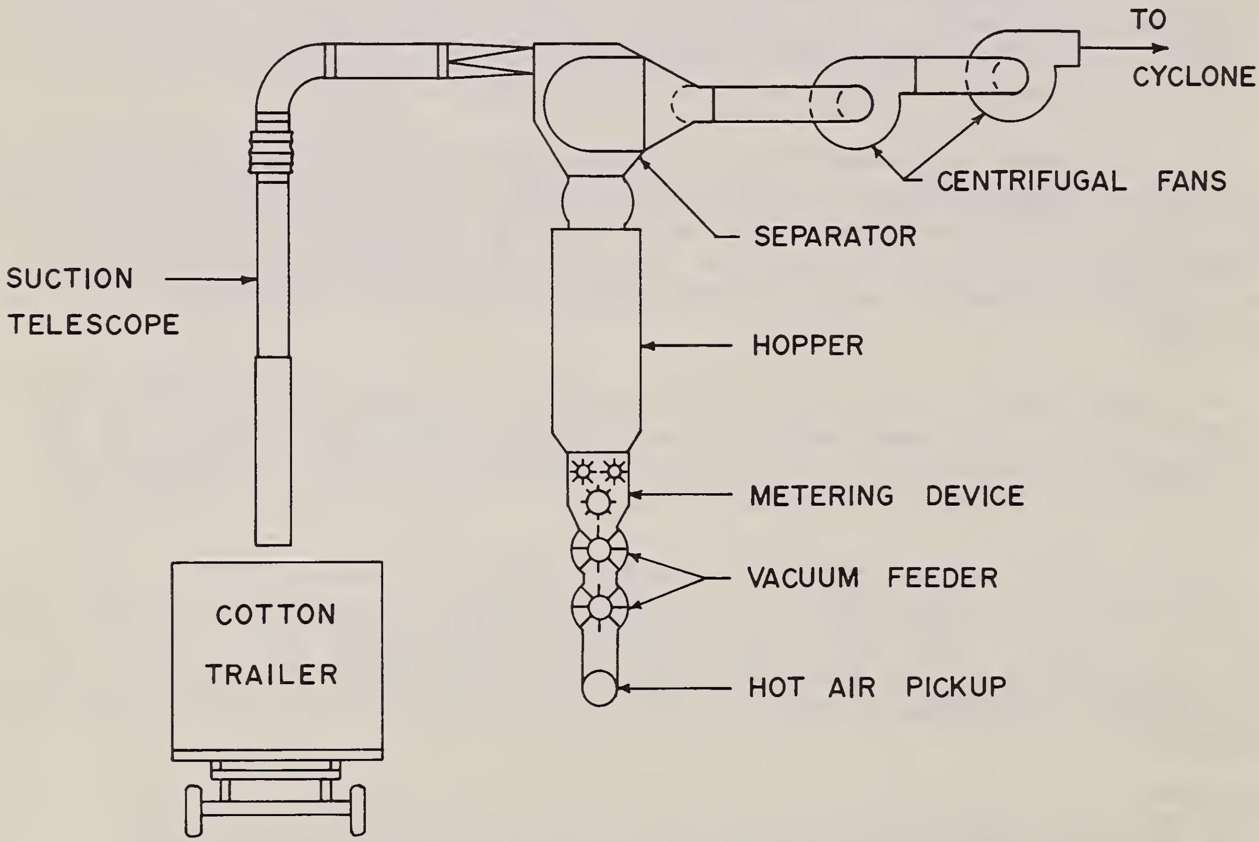

Figure 1. Schematic of a conventional pneumatic seed cotton unloading system.

of a conventional pneumatic unloading system that requires 65 to 180 horsepower, depending upon the required rate, to move the seed cotton from the trailer into the gin and meter it to the drying and cleaning system.

EXPERIMENTAL UNLOADING SYSTEM

Side-Dumping Trailer

The simplest way to reduce horsepower requirements is to eliminate the pneumatic handling system. This can very easily be done by dumping the load of seed cotton from a side-dumping trailer into a large hopper and mechanically conveying the seed cotton to the automatic feed control that would form a part of the unloading system.

The trailer was designed so that the running gear could be anchored down on one side and the bed pivoted on the opposite side (fig. 2). One vertical

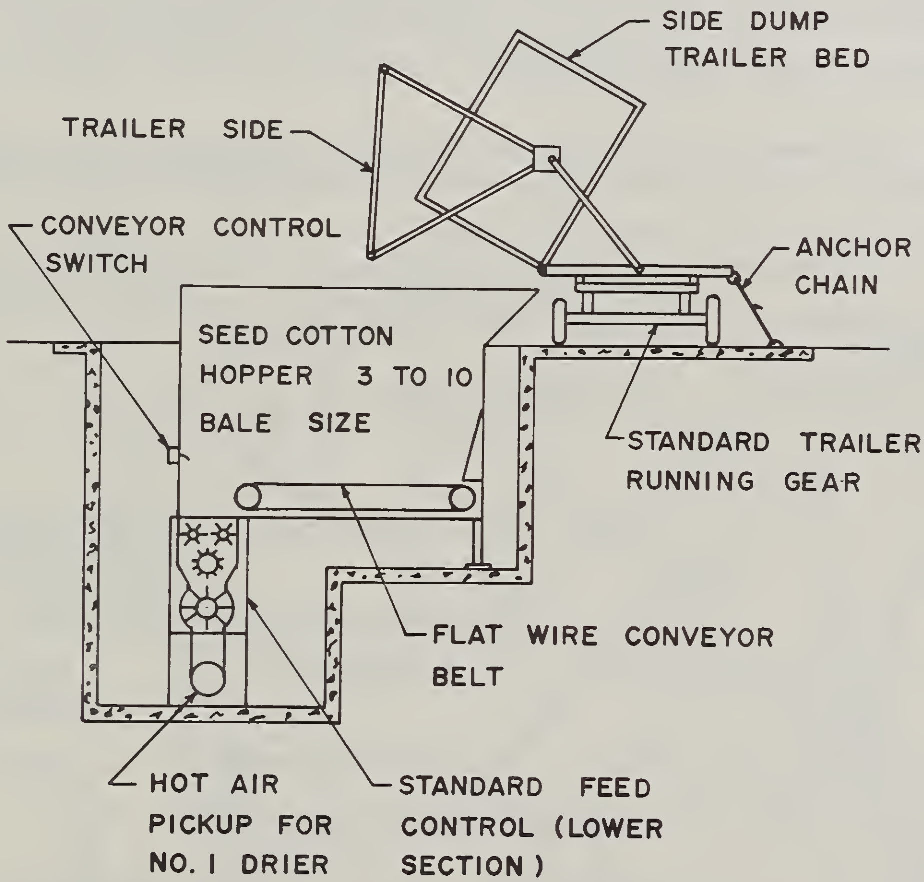

Figure 2. Experimental seed cotton unloading system with standard feed control lower section.

side of the trailer is hinged so that it lifts up and out as the trailer is dumped. The angle of dump is approximately 40 degrees. The one bale experimental trailer designed and fabricated for this unloading system worked satisfactorily without any modification.

The three operational arrangements of the experimental unloading system, using the one bale, side-dumping cotton trailer are discussed.

Horizontal Conveyor Belt

A seed cotton hopper 6 feet wide and 4 feet deep with the bottom formed by an endless conveyor belt made of 3/8-inch by 0.047-inch flat wire with 1/2-inch by 1-inch mesh, was designed and constructed to accommodate the cotton from the one bale trailer. At one end of the belt a lower section of a standard feed control unit was installed as indicated in figure 2. This arrangement failed to work because the cotton bridged across the opening above the feed rollers. Also in some sections of the Cotton Belt, the required 10- to 15-foot depth below ground of the hopper would be almost impossible.

Inclined and Horizontal Conveyor Belt

Another arrangement of a mechanical seed cotton unloading system is shown in figure 3. An inclined conveyor belt was added at one end of the

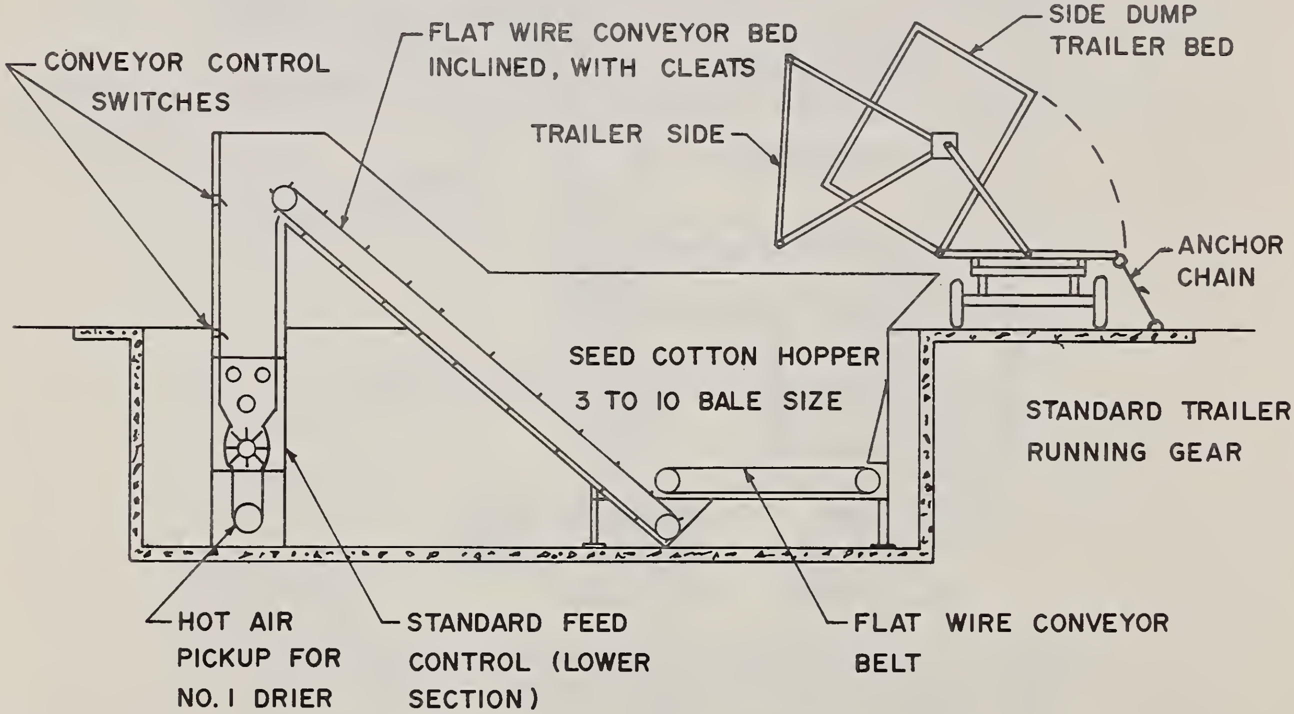

Figure 3. Experimental seed cotton unloading system with inclined conveyor to a standard feed control unit.

endless conveyor belt. This arrangement could be installed in a shallow pit, but the overall length of the system would be increased.

The horizontal conveyor belt was the same as the first arrangement, and the inclined conveyor belt consisted of 1/2-inch by 1-inch flat wire equipped with cleats to move the cotton up the incline to the feed control hopper. The cleats in the form of a tooth 1/8-inch thick, 1 3/4-inch high angled forward 30 degrees from the perpendicular. The cleats were located on the belt in rows 1 foot apart, with 16 cleats per row. The incline was set at 45 degrees to the horizontal.

The horizontal conveyor was driven at a speed of 10 feet per minute and the inclined conveyor at 136 feet per minute. The incline conveyor was operated at a higher speed to break up cotton wads and deliver a uniform amount of cotton to the feed control.

The 45 degree incline was found to be a little high for smooth operation with cleats and impossible without cleats. It is questionable whether the incline arrangement could be modified and made to operate on a commercial basis.

Feeder Cylinders in a Vertical Plane

A third arrangement of the equipment (figures 4 and 5) was tested and found to work satisfactorily. The feed rollers now located in a vertical

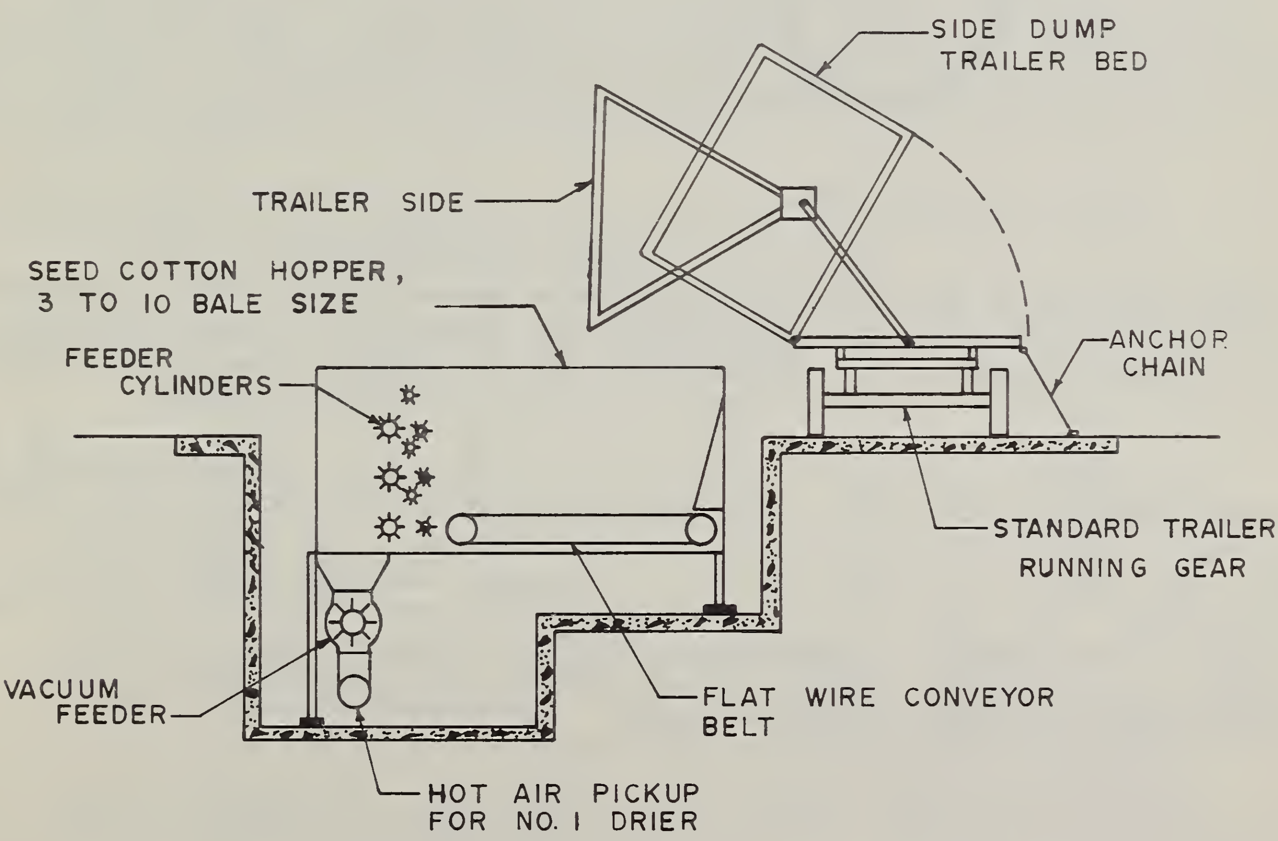

Figure 4. Experimental seed cotton unloading system with feeder cylinders in a vertical plane.

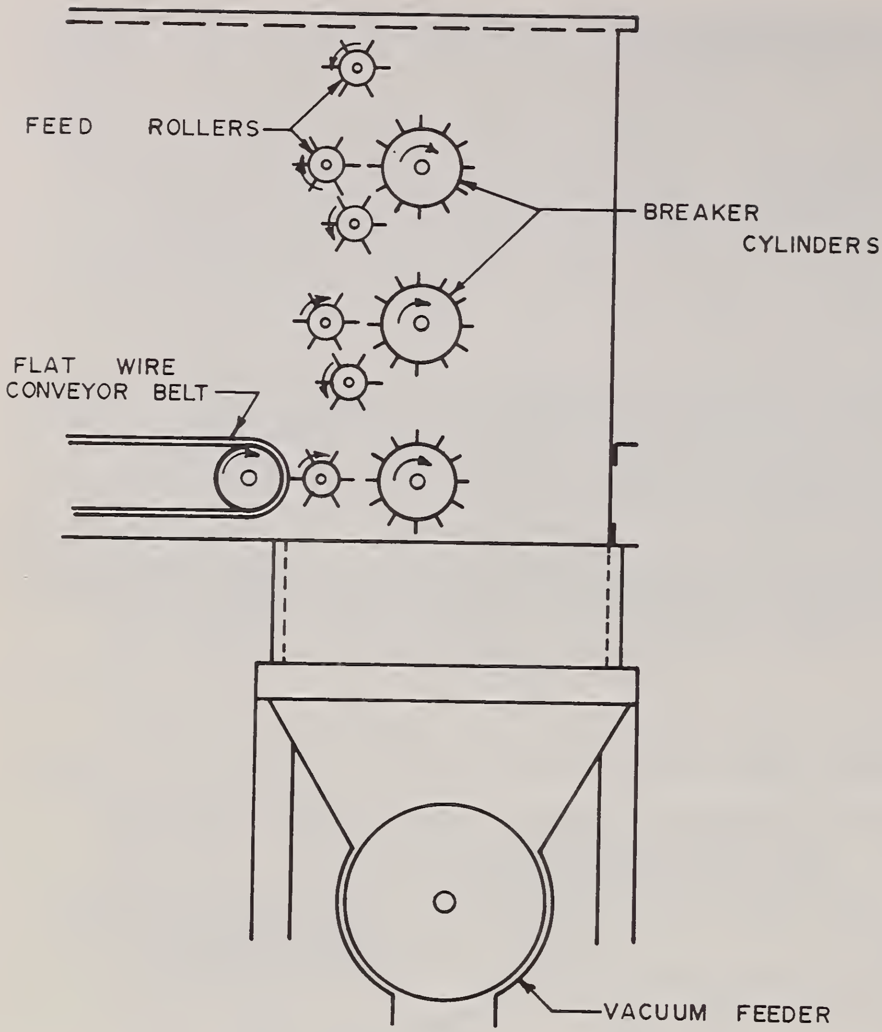

Figure 5. Cylinder arrangement of feeder section.

plane at the end of the conveyor belt receive the cotton from the moving belt and direct it to the breaker cylinders at the desired rate. Here, the wads of cotton are broken up and then fall by gravity into the vacuum feeder which drops the cotton into the hot airstream of the first drying system.

The complete experimental system is shown in figure 6. The prototype of the receiving hopper was 4 feet deep, 6 feet wide, and 10 feet long. Since the seed cotton slides from the trailer into the receiving hopper on its side, the depth of the hopper should be equal to or greater than the width of the trailer. The width of the hopper should be greater than the depth of the trailer and the length of the hopper should be slightly longer than the trailer. To eliminate spillage during dumping, the opposite side of the hopper from the trailer should be higher.

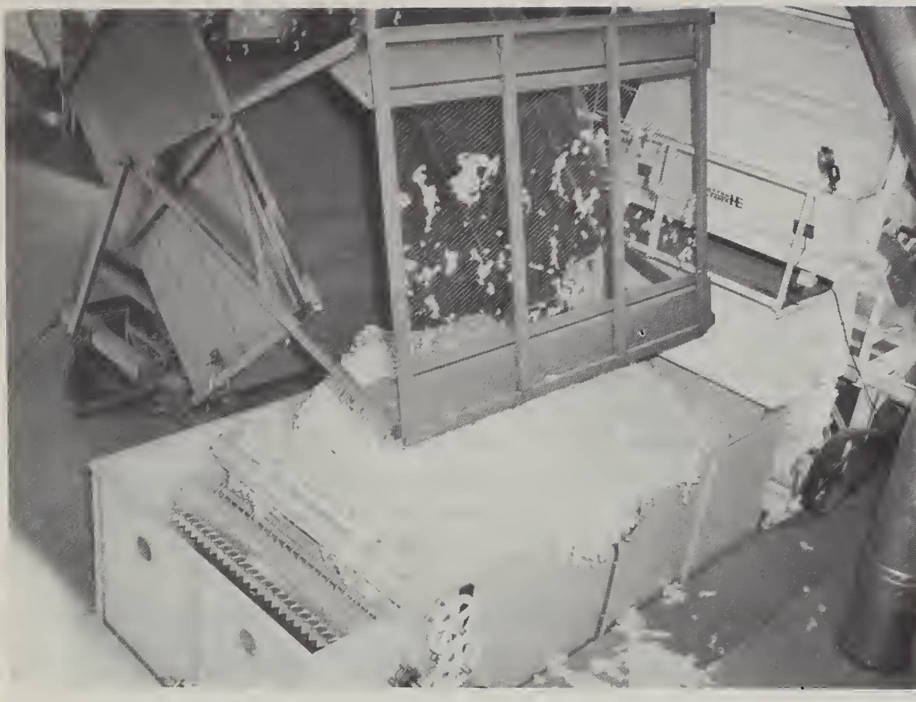

Figure 6. Experimental system being tested.

Power Requirements

For convenience, an overhead cable hoist was used to dump the trailer of seed cotton into the experimental feed hopper; however, a hydraulic or air cylinder could perform this operation just as well. The estimated energy requirement to unload side-dumping trailers with an electric cable hoist is shown in table 1.

Table 1. Estimated energy required to unload side-dumping trailers.

Trailer size	Electric cable hoist			Energy required per bale at full load 1/
	Capacity	Lifting speed	Connected horsepower	
	Pound	Feet per min.	Horsepower	Watt per hour
3 bale	4,000	20	3.0	6.2
5 bale	5,000	20	5.0	6.2
10 bale	12,000	20	7.5	4.7

1/ $Q = \frac{hp. \times 746 \times t}{bales \times 60}$ where

Q = Energy consumed per bale in watt-hours.

hp = Connected horsepower.

t = Time required to complete the unloading cycle in minutes.

Bales = Average of 1,500 pounds of seed cotton, trash and moisture for machine-picked cotton.

The feed rollers and conveyor belt that form the bottom of the hopper are geared together and driven by a two horsepower variable speed electric motor equipped with electronic controls. Breaker cylinders and vacuum feeder are driven by a five horsepower electric motor at a constant speed and separate from the other equipment.

The number of feed rollers is dependent on the depth of the hopper and diameter of the feed rollers. Three sets of 7-inch diameter feed rollers were used in the experimental equipment with one 12-inch diameter breaker cylinder for each set of feed rollers. Speed of the feed rollers was varied from 0 to 25 r.p.m., while the breaker cylinders were operated at 450 r.p.m.

The depth of seed cotton in the hopper will not always be uniform, especially as the last part of a load is being fed into the ginning system. As a result the uneven feed rate can become a problem and reduce the overall efficiency of the plant.

A system of limit switches and resistors was devised to automatically vary the speed of the feed mechanism when this uneven depth of material exists. A rod-operated limit switch was mounted on the outside wall of the hopper at each end of a set of feed rollers. The rod actuator extended through a hole in the wall into the hopper at a point between each set of feed rollers to sense whether cotton is present or not. These switches are connected in the control circuit of the variable speed feeder motor to automatically change the speed of the drive as the depth of cotton changes. This is accomplished by connecting a resistor in parallel with the limit switch to increase or decrease the resistance in the control circuit, and thereby change the speed of the drive by a predetermined amount. A master potentiometer located at the control center of the gin would still select the overall feed rate to match the processing rate of the gin plant.

Energy and power requirements determined on each component of the unloading system at five feed rates are shown in tables 2 and 3, and figure 7. The experimental system could not be tested above 24.5 bales per hour because of chokage of the high capacity conveyor distributor over the gin stands.

The power increased on a straight line relationship with capacity as would be expected. The minimum energy consumption per bale was between 18 and 20 bales per hour which would be the most efficient operating point for this particular system.

Table 2. Energy required for experimental unloading system.

Units	Connected electric power	Energy required per bale at 5 feed rates				
		4.6 bales per hour	8.9 bales per hour	11.7 bales per hour	19.7 bales per hour	24.5 bales per hour
	Hp.	W.-hr.	W.-hr.	W.-hr.	W.-hr.	W.-hr.
Hoist for dumping trailer[1/]	5	5.7	11.0	14.5	24.4	30.4
Feed rollers and conveyor belt	2	297	133	98	71.5	56.8
Breaker cylinders and vacuum feeder	5	316	193	172	174	168
Totals	12	619	337	285	270	255

1/ See table 1 using 5 bale trailer.

$$\text{W.-hr.} = \text{Full load energy} \times \frac{\text{processing rate (bales/hr.)}}{\text{trailer size (bales)}}$$

Table 3. Power required for experimental unloading system.

Units	Connected electric power	Power required per bale at 5 feed rates[1/]				
		4.6 bales per hour	8.9 bales per hour	11.7 bales per hour	19.7 bales per hour	24.5 bales per hour
	Hp.	Hp.-hr.	Hp.-hr.	Hp.-hr.	Hp.-hr.	Hp.-hr.
Hoist for dumping trailer[2/]	5	0.04	0.13	0.23	0.64	1.0
Feed rollers and conveyor belt	2	1.8	1.6	1.5	1.89	1.87
Breaker cylinders and vacuum feeder	5	1.9	2.3	2.7	4.59	5.52
Totals	12	3.7	4.0	4.4	7.1	8.4

1/ $\text{Hp.-hr.} = \frac{\text{watt-hr.}}{746} \times \text{bales/hr.}$

2/ See table 1 using 5 bale trailer.

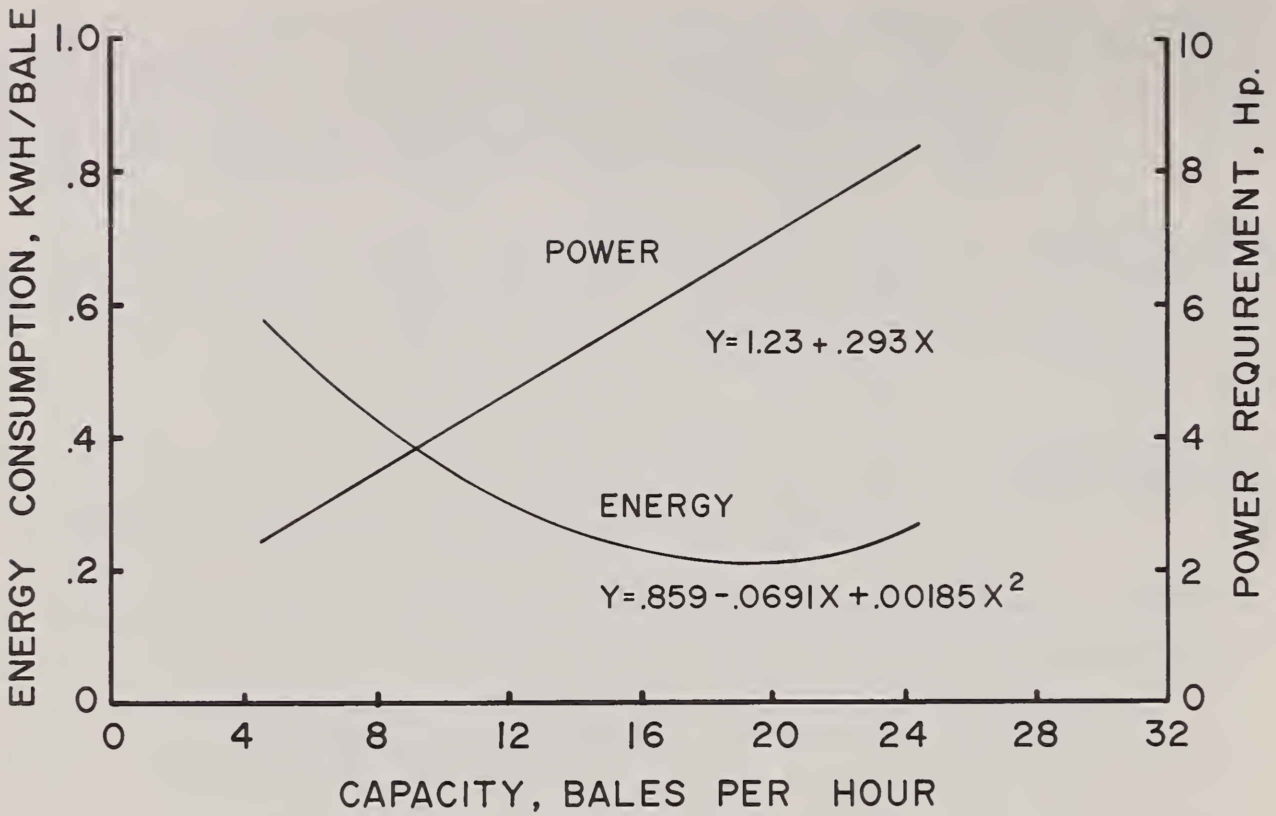

Figure 7. Energy and power requirements for experimental seed cotton unloading system. (One bale = 1,500 lb. of machine-picked cotton.)

From results of tests on the experimental unit, this system is even more economical at high capacities. A gin plant with a capacity of 40 bales per hour would require twice the connected horsepower of the experimental unit for the feed rollers, breaker cylinders, and vacuum feeder. A five-bale trailer would only require eight dumps per hour or one every 7-1/2 minutes; hence, the connected horsepower for dumping would be the same. Therefore, a total of approximately 20 connected horsepower would be required for a 40-bale-per-hour plant and would consume approximately 15 horsepower during operation. This would compare to about 200 horsepower and a six-man minimum crew for a conventional system. Even if two men are required to handle the yard and dumping operation, this system would be a tremendous saving in power and in labor.

Commercial Application

In applying this principle of materials handling at a cotton gin, the seed cotton trailer and receiving hopper must be designed to match each other; that is, the depth of the hopper should correspond to the width of the trailer and the width of the hopper to the depth of the trailer. For most efficient plant operation, especially at high capacities, it would be best to have two receiving hoppers and two feeding mechanisms discharging into a common vacuum feeder (fig. 8). Operating the hoppers alternately would eliminate any delay

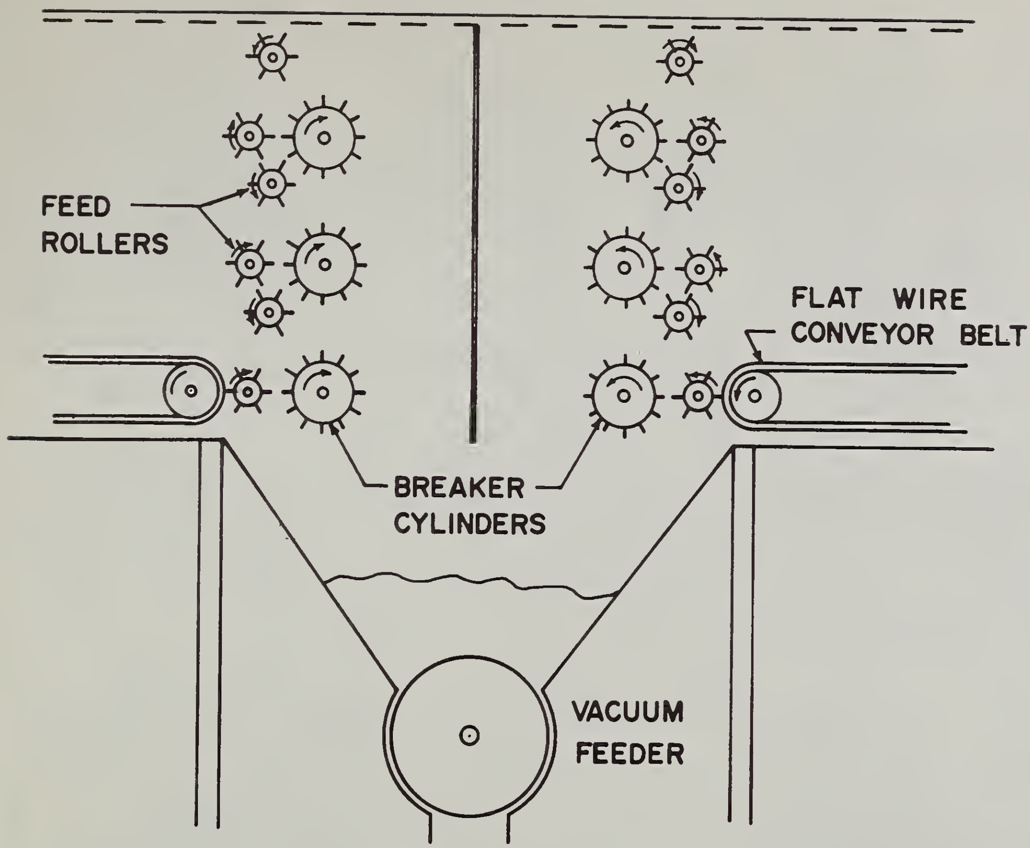

Figure 8. Cylinder arrangement for a system with two receiving hoppers.

in dumping the trailers or in feeding cotton to the gin plant. Each receiving hopper could be mounted on load cells and connected to a remote weight readout station to aid in computing the number of bales in each load.

Table 4 shows a reduction in energy cost from 19.6 to 0.84 cents per bale, or a 95.7 percent saving in favor of the experimental system over the conventional pneumatic system. The labor required to operate the pneumatic system, including moving trailers to and from the suction telescope, is a minimum of three men per shift.[4/] On the other hand, one man could keep a 12- to 15-bale-per-hour plant supplied with cotton, using the side dumping trailer unloading system, with time left for miscellaneous jobs around the gin. This would amount to a two-thirds saving in labor cost at this ginning rate and even greater savings at higher capacities. One man using this system could handle about 35 to 40 bales per hour in five bale trailers.

4/ Cable, C. C., Jr., Looney, Z. M., and Wilmot, C. A. Utilization and Cost of Labor for Ginning Cotton. U.S. Dept. Agr., Agr. Econ. Rpt. 70. 31 pp. 1965.

Table 4. Comparison of conventional and experimental unloading system for a 12- to 15-bale-per-hour plant.

System	Electric power load			Energy consumption per bale	Energy cost per bale 1/
	Connected	Operation	Idling		
	Hp.	Hp.	Hp.	Kw.-hr.	Cents
Pneumatic 2/	102	72.3	73.8	6.53	19.6
Experimental	12	4.4	2.7	.28	.84
Saving	90	68	71.1	6.25	18.76

1/ Based on 3 cents per kw.-hr. 2/ See footnote 3, page 1.

SUMMARY AND CONCLUSIONS

The unloading system of a modern high-capacity gin plant can be required to handle as much as 20 to 25 thousand pounds of seed cotton per hour or 15 to 20 bales. A minimum of three to four men are required for this unloading and yard operation. The power requirement ranges from 65 to 180 horsepower depending on plant layout, rated plant capacity, and method of harvest.

The objective of this study was to develop a more economical seed cotton unloading system that could keep pace with the ever-increasing demand for higher rates of processing at the gin.

A trailer was designed so that the running gear could be anchored down on one side and the bed pivoted on the opposite side. The pivoting side of the trailer is hinged so that it lifts up and out as the trailer is dumped.

A seed cotton hopper was designed and constructed to accommodate the cotton from the trailer. The bottom of the hopper was formed by an endless flat wire conveyor belt.

Several arrangements of the feed mechanisms were tested during the development of the unit. The arrangement that proved satisfactory was with the feed rollers located in a vertical plane at the end of the horizontal conveyor belt and backed up by breaker cylinders. The load of seed cotton is moved to the feed rollers by the conveyor belt which directs the cotton to the breaker cylinders at the desired rate to satisfy the gin plant capacity. Here the wads of cotton are broken up and then fall by gravity to a vacuum feeder which delivers the cotton into the hot air stream of the first drying system.

Energy and power requirements were determined on each component of the experimental unloading system at five feed rates. By selecting a ginning rate of 12 to 15 bales per hour for comparison of the experimental to a pneumatic system, substantial savings in power and labor were found.

The experimental system can reduce the average connected horsepower from 102 to 12 horsepower with a 95.7 percent reduction in consumed power cost. Labor requirements can be reduced by two-thirds at this ginning rate and more at higher capacities. It is estimated that from 35 to 40 bales per hour can be handled in five bale trailers by one man using the experimental unloading system.